5 J. Sus. Agric. Sci. **Vol. 50,** No. 4, pp: 47 - 68 (2024)

Journal of Sustainable Agricultural Science
http://jsas.journals.ekb.eg/

Maintain The Quality of Winter Guava (Psidium guajava L.) Fruits By Post-Harvest Application of Melatonin and Methyl Jasmonate Under Vacuum-Packaged and Low-Temperature Storage

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TWO distinct seasons were conducted; winter guava (*Psidium guajava* L.) fruit treated with melatonin and methyl jasmonate (MeJA) under different concentrations and combined with vacuum packaging were stored at 4 ± 1°C with 90 ± 5% RH. The results showed that the microbial load (CFU/g) decreased when melatonin and methyl jasmonate were present in high concentrations under vacuum packing. Additionally, these treatments resulted in a substantial reduction ($p<0.05$) in weight loss percentage. However, no chilling injury (CI) was observed in guava when stored at 4°C at melatonin (0.2 mM) under vacuum packaging. Simultaneously, it indicated that the most effective treatment in decreasing respiration rate and maintaining higher acidity and ascorbic acid was MeJA (2mM) under vacuum packaging. Therefore, melatonin and MeJA at high concentrations under vacuum packaging could maintain chlorophyll degradation due to reducing softening, weight loss %, and microbial load in winter guava fruits during storage periods compared to other treatments and control. Conclusively, applying melatonin and MeJA at a high concentration under vacuum packaging enhanced chilling tolerance and maintained the quality of guava fruit at 4°C for 28 days.

Keywords: Chilling Injury; Guava fruit; Vacuum Packaging; Melatonin; Methyl. Jasmonate; Weight loss.

1. Introduction

Guava (Psidium guajava L.), a widely consumed fruit, is abundant in essential nutrients such as vitamins and minerals crucial in maintaining human health (Vijaya Anand et al., 2020). It is mostly grown in tropical and sub-tropical locations across the globe. Guava surpasses other tropical fruits' yield, resilience, flexibility, and nutritional content, resulting in greater financial gains for growers with fewer resources. In Egypt, most winter guava output goes towards export, highlighting the necessity for post-harvest procedures to maintain overall quality and extend shelf life storability (El-Bana and Ennab 2023). Moreover, it is climacteric and undergoes quick post-harvest ripening within a few days under normal conditions; it ripens and turns overripe and mealy within a week. When stored in a cold environment, the fruit can preserve its quality for 15 days at a temperature of 8-10 °C and a relative humidity of 85-90% (Gill, 2018).

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Received: 20/10/2024; Accepted: 20/12/2024
DOI:10.21608/JSAS.2024.329264.1491

Fungal infection of fruit causes post-harvest losses of fresh fruit due to the development of fruit diseases. Post-harvest losses account for around 30% of harvested fruits that do not reach customers' plates. Fungal diseases significantly contribute to these losses since they are responsible for most fruit decay and customer grievances. Gaining comprehension of fungal pathogenic processes and control mechanisms is crucial for developing disease prevention and treatment strategies (Bano et al., 2023). Furthermore, fungal infections can alter the appearance and chemical makeup of fruits, leading to acid formation, sugar degradation, and microbial byproducts. This increase in mycotoxin production raises concerns about food safety due to its potential health risks (Welke, 2019)taste, and color of juice and wine. In addition to this sensory effect, the occurrence of filamentous fungi in grapes may result in mycotoxins, including alternariol, aflatoxins, tenuazonic acid, fumonisin B2, ochratoxin A (OTA. Additionally, this crop has constraints in terms of commercialization owing to its limited storage life after harvest and susceptibility to infections and chilling injury during storage (Yadav et al., 2022). Several recent research studies had investigated safer and ecologically sustainable solutions for preserving the quality of guava fruit. Several recent research studies have investigated safer and ecologically sustainable solutions for controlling fungal spoilage and preserving the quality of fruit (Elmenofy 2021; Choupdar et al., 2022), chemical methods (Singh et al., 2023), and physical methodologies (Killadi et al., 2021; Zhang, 2024). Several recent research studies had investigated safer and ecologically sustainable solutions for preserving the quality of guava fruit. Several recent research studies have investigated safer and ecologically sustainable solutions for controlling fungal spoilage and preserving the quality of fruit (Elmenofy 2021; Choupdar et al., 2022), chemical methods (Singh et al., 2023), and physical methodologies (Killadi et al., 2021; Zhang, 2024).

Cold storage is a post-harvest technology used to preserve the quality of horticulture products until they are ready for human consumption (Arbelet-Bonnin et al., 2022). Nevertheless, guava fruit is susceptible to chilling disorder when stored at cold temperatures below 8- 10°C, leading to alterations in the lipids of cell membranes (Alba-Jiménez et al., 2018). Chilling injury (CI) is a severe condition that affects fruit after it has been harvested. It occurs when the fruit is exposed to low temperatures during storage (Elmenofy and Ketta, 2021), caused by a lack of energy inside the cells and a decrease in the integrity of the cell membranes (Alba-Jiménez et al., 2018). The produce must be stored at a temperature above the chilling threshold to prevent chilling injury. However, this might decrease nutritional value and taste (Ali et al., 2022). Consequently, other storage techniques must be used to extend the longevity of this fruit. Previous research indicated that low-temperature storage is an efficient way to control disease growth and postpone the quality deterioration of guava. In a study conducted by Murmu and Mishra, (2018), it was shown that guava maintained at a temperature of 4 °C, with 3 g of ethylene scavenger (ES) and 46 g of moisture sorbent (MS), had the least amount of chilling injury. These guavas exhibited a brighter color, reduced hardness, and the greatest percentage (95.33%) of guavas that were deemed acceptable compared to the other treatments. Furthermore, Zhang, (2024) found that extended periods of cold shock (6, 9, and 12 hours) before storage at a constant temperature of 4°C greatly enhanced the quality and longevity of guava storage. It was achieved by slowing the rate of chilling injury, minimizing weight loss, preserving firmness, and enhancing the nutritional value of the fruit. The researchers suggest that applying numerous studies may effectively reduce chilling injury, prolong the shelf life, and preserve the quality of guava when stored at low temperatures, such as trehalose (Vichaiya et al., 2022a), melatonin (Fan et al., 2022a), cold shock (Zhang, 2024), ATP (Vichaiya et al. 2022b), L-arginine (Ali et al., 2022), near-freezing temperature (Xiao et al., 2022). Therefore, it is vital to discover a viable resolution to decrease the occurrence of decay, chilling injury, and maintain the quality of guava fruit post-harvest during these conditions.

Modified atmosphere packaging (MAP) is a post-harvest process that involves reducing oxygen levels and increasing carbon dioxide levels in the surrounding air (Alba-Jiménez et al., 2018). Reduced respiration rates and water loss are two outcomes of using modified atmosphere packaging (MAP) technology, extending perishable commodities' shelf life (Lufu et al., 2021)non-perforated 'Decco', non-perforated 'Zoe', micro-perforated Xtend®, 2 mm macro-perforated high density polyethylene (HDPE. Vacuum packing is a method used to extend the longevity of food commodities, placing the product in a tightly sealed container, removing the air from it, and then sealing the package (Nasrin et al., 2022). By creating a vacuum surrounding the products, the oxygen levels in the packing are decreased, which prevents the growth of aerobic organisms and prevents the product from spoiling (Fernandes et al. 2020)polyethylene (PE. Vacuum packing is mostly used for dehydrated food, such as grains, appetisers, preserved meats, and seafood (Nagarajarao, 2016). However, studies have been scarce on using vacuum packaging to preserve fresh fruits and vegetables (Nasrin et al., 2022). Nevertheless, a study by Rocha et al., (2007) discovered that vacuum packing of freshly cut or barely processed carrots that were peeled positively impacted their color, sugar content, and the presence of phenolic compounds. Additionally, the vacuum packaging allowed the carrots to have a shelf life of 7 days when stored at a temperature of 4°C. Melatonin, a safe and nontoxic chemical, is extensively researched for its ability to enhance fruit storage life and quality in post-harvest preservation (Fan et al., 2022a).

Melatonin has a role in various physiological processes in plants, including responses to biotic and abiotic stress (Li et al., 2022a, c), enhancing antioxidant activity and reducing fruit oxidative damage by inhibiting the increase in pericarp cell membrane permeability (Cai et al. 2024a). A study by Fan et al.)2022a) discovered that the application of Melatonin had a substantial positive impact on both the quality and chilling damage of guava cv. Xiguahong fruit when kept at a temperature of 4 ± 1 ◦C. Furthermore, Gao et al., (2016) provided evidence that melatonin can decelerate the senescence process and enhance the cold tolerance of peach fruit. The addition of external melatonin enhanced the ability of the fruit to withstand cold temperatures during storage, resulting in a decrease in pericarp browning and a delay in senescence (Shah et al., 2023). The application of melatonin suppresses the growth of gray mold and stimulates the development of disease resistance in apple fruit after it has been harvested (Sun et al., 2021). Melatonin significantly reduced chilling damage, malondialdehyde levels, and electrolyte leakage in guava fruit, enhancing total phenolic compounds and antioxidant activity. It also improved membrane integrity and reduced phospholipase D and lipoxygenase activity, suggesting that melatonin could alleviate post-harvest chilling issues in guava fruit (Arbelet-Bonnin et al., 2022; Fan et al., 2022a). The data imply that melatonin positively regulates cell-wall-modifying enzymes and proteins in peaches, leading to the depolymerisation of cell-wall polysaccharides and progressive softening during cold storage. This reduction in mealiness is attributed to the effects of melatonin (Cao et al. 2018). Disinfectants containing chemical fungicides raise additional issues related to pollution, human health, and the development of resistant strains to the chemicals. Furthermore, due to countries' increasingly stringent regulations regarding the amount of residue allowed in imported and exported fruit, natural antimicrobials like essential oil should be considered as an alternative (Vilaplana et al., 2018; Reyes-Jurado et al., 2020; Pinto et al., 2021).

Using natural ingredients such as organic extracts or botanical oils is one of the most beneficial and secure approaches to managing post-harvest infections (Pinto et al., 2021). Essential oil treatments have two separate ways of regulating post-harvest diseases: a direct impact on pathogens (Gonçalves et al., 2021) and an indirect effect by inducing pathogenesis-related (PR) expression i.e. β-1,3-glucanase and chitinase (Bill et al., 2017). Methyl Jasmonate (MeJA) is a naturally occurring molecule that is used both before and after harvest to prolong the shelf life and preserve the quality of goods (Saracoglu et al., 2017; Aslantürk et al., 2022). MeJA treatment enhances antioxidant activity during the post-harvest period by stimulating the activities of various antioxidant capacities and activating disease resistance (Xie et al., 2024). In addition, the application of MeJA enhances the stability of the membrane structure and reduces lipid peroxidation (Bagheri and Esna-Ashari, 2022a)16, and 24 μL L − 1. The use of MeJA in post-harvest treatment of horticultural crops is noteworthy for preserving storage quality, prolonging senescence, and enhancing resistance responses. Methyl jasmonate (MeJA) treatment after harvesting has been shown to increase the concentration of bioactive chemicals, enhance antioxidant systems, and improve disease resistance in different crops, such as blueberry fruit (Wang et al., 2019a), Kinnow mandarin (Dhami et al. 2022), pomegranate fruit (Chen et al., 2021), and persimmon fruit (Bagheri and Esna-Ashari, 2022a)16, and 24 μL L − 1. According to Jiang et al., (2015), gray mold degradation in harvested fruits may be reduced by treating them with MeJA, which primes defensive responses for better disease resistance against Botrytis cinerea. Methyl jasmonate is essential for reducing post-harvest losses, increasing antioxidant capacity, lengthening storage life, and building stress tolerance (Asghari and Hasanlooe, 2016). By stimulating the formation of H_2O_2, MeJA treatment has the potential to enhance the antioxidant capacity of fruits after harvest (Wang et al., 2019). Methyl jasmonate has already been used successfully in valencia orange fruit (Rehman et al., 2018), pomegranate (Saba, 2019), mandarin (Dhami et al., 2022), dragon fruit (Mustafa et al. 2018), and guava (González-Aguilar et al., 2004).

Hence, it is important to discover a viable resolution to diminish the occurrence of decay and chilling injury, enhance the quality of guava fruit post-harvest, and prolong storage time. In light of those mentioned above, this study sought to determine how melatonin and methyl jasmonate treated guava fruits for four weeks in vacuum packing at 4°C affected their microbiological quality, fruit quality, and storability.

2. Materials and Methods

The local genotype of the winter guava fruit (Psidium guajava L.) was obtained from a private orchard in Baltim region, Kafr El-Sheikh Governorate, Egypt (Latitude: N 31o07'39"; Longitude: E 30o40'55"), with color values of L* = 43.62, a* = -13.02, and b* = 17.06. At the point of maturity, when the fruit's skin had a yellowish-green color, harvesting occurred on February 12th and 7th, 2022 and 2023, respectively. The fruits were collected in the morning and transported to the Physiology & Breeding of Horticultural Crops Lab at the Faculty of Agriculture, Kafrelsheikh University, Kafr El-Sheikh, Egypt. The experiment was conducted throughout two seasons, 2022 and 2023. The purpose was to investigate the impact of various post-harvest treatments on guava fruits' quality and storage capability.

Preparation of guava fruit, and treatment application

Undamaged fruit that were consistently sized were chosen, washed, and immersed in a 0.2% sodium hypochlorite solution for 10 minutes, and allowed to air dry at room temperature, following the drying process, the fruits were subjected to treatment applications. A total of 600 fruits were divided into two main groups; the first group was without a vacuum, and the second group was vacuumed using a vacuum packaging at 50%, by using Machine Model ("SINBO " Model No. DZ-280/2SD, China) and placed into polyethylene film bag (50 µm), size of the bag was 23 cm x 18 cm. In the case of the modified atmosphere pack, fruits were sealed in polybags, while the second group of fruits was kept unwrapped. There were three fruits per pack and three replicates per treatment. Each pack served as one replicate. The two groups distributed on five treatments (control (T1), dipping in melatonin at 0.1mM (T2), melatonin at 0.2 mM (T3), methyl jasmonate at 1mM,(T4), and methyl jasmonate at 2mM (T5), for ten minutes). Melatonin and Methyl jasmonate were purchased from Sigma Aldrich, Egypt. The fruit was immersed in various melatonin concentrations. It was solubilized in ethanol (Fan et al., 2022a) and then diluted to 1mM and 2mM for the experiment. Methyl jasmonate was diluted to 0.1mM and 0.2mM for the experiment. (Tween-80 at 0.5% was added as an emulsifier). The fruits were immersed in the solution for ten minutes and kept at room temperature (22 ± 2 ◦C) to dry air for 30 minutes. Subsequently, the two group fruits were stored in 40 × 25 × 15 cm carton boxes and kept at 4 ± 1 ◦C with a relative humidity of 85-90%. Every treatment contains 60 fruits distributed in three replicates (20 fruits). The quality indicators were used to examine the fruits regularly. Samples were analyzed at 7, 14, 21, and 28 days plus one day at room condition.

Measurements and analysis
Microbial load measurement

Three randomized samples from each treatment were taken at 14 and 28 days of storage to determine microbial growth. The colonies of mold, yeast, and mesophilic aerobic bacteria count. All microbial counts were expressed as Log colony-forming units (CFU) per g of fruit fresh weight (Sogvar et al., 2016).

Chilling Injury Index

Five guava fruits were selected to evaluate chilling damage. The assessment was based on five distinct levels, which measured the extent of pitting or browning on the surface of the fruits. The value 0 denotes no browning, whereas the values 1, 2, 3, and 4 correspond to browning percentages of 1-10%, 11-25%, 26-50%, and more than 51% accordingly (Chen et al., 2022). The chilling injury index was determined using the following formula:

∑ (Chilling injury level / Maximum level of chilling injury × The ratio of corresponding guavas in each level of chilling injury).

Fruit weight loss percentage (%)

In the first stage of the experiment, a digital balance (EK600H-Japan) was used to weigh five pieces of fruit. These same fruits were then measured again at 7-day intervals during storage. The weight reduction percentage was determined using the following equation: The weight loss percentage calculated using the formula: [(Initial weight of fruit - Weight of fruit at each sampling time) / Initial weight of fruit] x 100.

Respiration Rate

The respiration rate (CO_2 production) was measured using the titration technique described by (Haney et al., 2008) and to date **the equipment and labor required have somewhat limited more widespread adoption of such methodologies. The purpose of this research is to compare the results of measured soil CO_2 respiration using three methods: (1**. The fruits were placed in respiration jars for one hour, and potassium hydroxide (KOH) was titrated with one normal (1 N) hydrochloric acid (HCl) using a thymol blue indicator. The amount of carbon dioxide (CO_2) produced was estimated as mg CO_2 kg^{-1} h^{-}

Fruit firmness (Newton, N/cm^2)

The fruit firmness (Newton(N)/cm^2) was assessed at harvest and weekly intervals throughout storage, and measuring the equatorial area of five fruits using a hand-held digital force gauge, Model FGV-50XY, equipped with an 8 mm diameter plunger tip from Shimpo company in Wilmington, NC, USA.

Total Chlorophyll (µg/ml)

Total Chlorophyll contents in the peel of guavas (three replicates) were determined according to the method (Wellburn, 1994). The absorbance of the extract was measured at a spectrum of 663 nm for chlorophyll a and 646 nm for chlorophyll b by using a spectrophotometer (UV/Visible spectrophotometer Libra SS0PC). The following equations calculated pigment contents:

Chlorophyll a (µg/ml) = 12.21 E663 - 2.81 E646 & Chlorophyll b (µg/ml)

= 20.13 E646 - 5.03 E663 and Total chlorophyll (µg/ml)

= chlorophyll a + chlorophyll b.

Fruit Color (L* & a* & b* Values)

Fruit color was determined in two opposite sides of the fruit after one day from all storage periods using a colorimeter (Minolta Co. Ltd., Osaka, Japan), as defined by (McGuire, 1992)and mar- keters often attempt to improve upon what nature has painted. In spite of the signifi- cance of color in our work, however, many researchers continue to analyze this charac- teristic inappropriately. The confusion that results is unnecessary; easily computed and readily understood measures are available to clarify color descriptions for researchers and marketers alike.","author":[{"dropping-particle"","family":"McGuire","given":"Raymond G.","non-dropping-particle":"","parse-names":false,"suffix":""}],"container-title":"HortScience","id":"ITEM-1","issue":"12","issued":{"date-parts":[["1992"]]},"page":"1254-1255","title":"Reporting of Objective Color Measurements","type":"article-journal","volume":"27"},"uris":["http://www.mendeley.com/documents/?uuid=8a99092b-a07c-407b-8073-a9d7bc66489f"]}],"mendeley":{"formattedCitation":"(McGuire 1992. Color components include L* (brightness), a* (redness and greens), and b* (yellowness and blue color), and three replicates were evaluated per treatment.

Soluble Solids Content (SSC%) and Total acidity (TA%)

During the storage period, the fruit's soluble solid content (SSC%) was measured using a Bellingham & Stanley digital refractometer Model: RFM 340-T. The acidity, expressed as a percentage of malic acid, was assessed using an automated titration device (TitroLine, Model TL 5000/20M2, SI Analytics), according to the (A.O.A.C, 2000).

Ascorbic acid (Vitamin C) (100 mg/100g fresh weight)

Ascorbic acid content was determined by titrating 3 mL of the juice with 3 mL of trichloroacetic acid (TCA) solution, which had a concentration of 5% w/v. The titration was carried out using a 2,6-dichlorophenolindophenol solution, with a concentration of 0.03% w/v until a sustained pink color shift was seen. Results were expressed as mg 100 g^{-1} of ascorbic acid on a fresh weight (A.O.A.C, 2000) using a standard curve that was made by different concentrations of ascorbic acid.

Statistical analyses

Initially, the data were evaluated for normality and homogeneity of variances using Shapiro-Wilk's and Levene's tests, respectively. A completely randomized design was used, consisting of two conditions: without vacuuming and packaging with vacuuming. This design included a total of five treatments and three duplicates. A combined analysis examined the data for two years (Moore and Dixon, 2015). The statistical analysis was conducted using SPSS version 26 (SPSS, Inc., Chicago, IL, USA), and significance was determined at a 95% confidence level ($p<0.05$). The variables of the year were combined since their error mean squares showed a difference of less than a factor of 10 and were determined to be homogenous.

Results and Discussion

Microbial load (count) (CFU/g)

The microbial count of guava fruits during storage for 14 and 28 days was notably different for the fruit dipped from un-vacuum and vacuum packaging systems and as a result of melatonin and MeJA applications, as shown in Table 1. At 14 days of storage, the microbial load in guava stored under non-vacuum conditions was 1.47 times higher than in the vacuum-packed control group. Melatonin treatment at 0.2 mM also showed a significant decrease in microbial load, particularly under vacuum conditions, where the load was reduced by 3.13-fold. Methyl jasmonate at 2 mM showed the most substantial reduction, with vacuum-packed guava at 1×10^2 CFU/g, resulting in a 4-fold decrease under vacuum conditions in comparison with non-vacuum-packed guava at 4×10^2 CFU/g. At 28 days of storage, the microbial load of guava under non-vacuum conditions was 1.77 times higher than that of vacuum-packed guava. Melatonin at 0.2 mM decreased the load, with non-vacuum-packed guava showing 6.3×10^2 CFU/g and vacuum-packed guava at 4.3×10^2 CFU/g. Methyl jasmonate at 2 mM treatment showed the most pronounced effect, with a microbial load of 4×10^2 CFU/g under vacuum conditions. In this respect, Fernandes et al., (2020) polyethylene (PE found that vacuum packaging (VP) treatments have a substantial impact on the suppression of microbial count of microorganisms compared to the control; by generating a vacuum around the items, the oxygen levels inside the packaging are reduced, inhibiting aerobic organisms' proliferation and preventing the product from deteriorating (Alba-Jiménez et al., 2018). Exogenous melatonin can preserve the quality of guava fruit and boost its disease resistance by enhancing the fruit's antioxidant and defence-related enzymatic activities of chitinase and phenylpropanoid pathway enzymes, in addition to preventing the development of the incidence of the disease (Fan et al., 2022a). As well as Melatonin enhances protection against Botrytis cinerea in fruit by stimulating the salicylic acid signaling system (Li et al., 2022a), and by activating defence responses (Li et al., 2022c). Furthermore, Sun et al., (2021) suggest that melatonin increases defensive enzyme activities, total phenolics, and lignin content, as well as the expression of pathogenesis-related (PR) and MeJA pathway-related genes.

The findings from Tian et al. (2023) demonstrated that MeJA enhances disease resistance by controlling the activation of H_2O_2 buildup and promoting the activities of defence-related enzymes. Moreover, the application of MeJA improves the plant's defensive reactions, resulting in heightened resistance to Botrytis cinerea and a decrease in the decay of harvested fruits caused by gray mold (Jiang et al. 2015). MeJA has an antimicrobial ability to regulate the phenylpropanoid pathway and jasmonate pathway (Li et al., 2022). MeJA has antioxidant and antimicrobial properties. It may indirectly reduce the susceptibility of tissues to infections by delaying the loss of firmness and slowing down the senescence of plant tissues (Andrys et al., 2018). In addition, Elmenofy, (2021) revealed that essential oils (EOs) may be used as a safe method to extend the storage life of fruits while maintaining their quality by reducing the percentage of decay without causing any damage to the fruit. Guo et al., (2017) suggest that the inhibition of bacterial and fungal development by essential oils (EOs) is caused by changes in the permeability and integrity of the cell membrane, leading to the leaking of nucleic acids and proteins. Application of methyl jasmonate (MeJA) after harvesting stimulates the activation of disease resistance in kiwifruit. MeJA markedly enhanced the activity and gene expression of enzymes associated with disease resistance, while suppressing the growth of lesion diameter (Xie et al., 2024).

Chilling Injury Index

As shown in Table 2, initially, while examining chilling injury in guava fruits in non-vacuum packaging, the control group had a chilling injury rate of 27.67% after 14 days, notably increasing to 30.99% by day 28. Conversely, the vacuum-packed group encountered chilling injury, which began at a rate of 6.42% and concluded at 8.25% throughout the same timeframe. Remarkably, dipping treatments at both concentrations reduced chilling damage considerably compared to the control group. The impact was more evident in the vacuum-packaging fruits, with the incidence dropping to 0.01% and 0.0% after 14 days and 1.81% and 0.0% after 28 days, respectively, for both concentrations of melatonin. The fruits subjected to vacuum packaging exhibited lower rates of chilling damage compared to those not subjected to vacuum packaging.

Table 1. Impact of melatonin and methyl jasmonate treatments on winter guava fruit under non-vacuum packaging and vacuum packaging conditions on a microbial count, CFU/g during storage.

Treatments	14 days		28 days	
	Non- vacuum	Vacuum	Non-vacuum	Vacuum
Control	6.3×10^2 a	4.3×10^2b	11×10^4a	6.2×10^4c
Melatonin (0.1 mM)	5.3×10^2ab	3.6×10^2bc	7×10^4 b	6×10^4c
Melatonin (0.2 mM)	5×10^2ab	1.6×10^2 d	6.3×10^4c	4.3×10^4e
Methyl jasmonate (1 mM)	5.1×10^2ab	2×10^2 cd	5.3×10^4d	5.6×10^4cd
Methyl jasmonate (2mM)	4×10^2b	1×10^2d	5×10^4d	4×10^4e

Different letters denote significant differences according to Duncan's test ($p<0.05$).

Table 2. mpact of melatonin and methyl jasmonate treatments on winter guava fruit under non-vacuum packaging and vacuum packaging conditions on chilling injury index.

Treatments	14 days 28 days			
	Non-vacuum	Vacuum	Non-vacuum	Vacuum
Control	27.67a	6.42cde	30.99a	8.25cd
Melatonin (0.1 mM)	8.13bc	0.01f	9.23c	1.81e
Melatonin (0.2 mM)	7.86cd	0.00f	9.09c	0.00f
Methyl jasmonate (1 mM)	26.12a	5.23de	15.22b	7.00d
Methyl jasmonate (2mM)	8.91b	4.11ef	14.11b	6.59de

The different letters denote significant differences according to Duncan's test at $p<0.05$.

Our study suggests that the application of melatonin to guava, together with vacuum packaging, may enhance the fruit's ability to withstand low temperatures and maintain its quality throughout storage. These findings align with previous studies by Chen et al., (2022) that discovered melatonin as a potential technique for improving the ability of cold-stored guava fruit to withstand low temperatures and prolong its storage duration. A study conducted by Madebo et al., (2021) discovered that fruits treated with melatonin showed a prolonged period of freshness after being harvested. Additionally, they noticed a delay in deterioration and a reduction in decay when stored at low temperatures, namely at 4 °C. In addition, the melatonin-treated fruits stored in cold storage showed a rise in GABA content, fatty acid ratios, and consequent high energy maintenance and supply in the form of ATP, which was controlled in peach fruit. Furthermore, Fan et al., (2022) demonstrated that melatonin functions as a potent reactive oxygen species (ROS) scavenger, effectively safeguarding fruits from oxidative damage and preserving their overall quality. MeJA prevents chilling injury by boosting antioxidant activities and improving the quality of fruits during storage at low temperatures (Li et al., 2023; Hasan et al., 2024)and to maintain the overall quality of the papaya fruit when stored at low temperature. Consequently, the effects of postharvest MeJA (1 mM. This effect is attributed to the complete elimination of malondialdehyde production (Cai et al., 2024b).

Weight loss percentage (%)

The findings are shown in Fig. 1, the analysis reveals a consistent pattern: when combined with melatonin and methyl jasmonate treatments, vacuum packaging significantly reduces guava's weight loss during storage across all storage time. The impact is more pronounced at higher melatonin and methyl jasmonate concentrations. Throughout the 28 days, the control group had the most significant weight reduction compared to other groups, especially when not using vacuum packing. The control group that was not subjected to vacuum packing saw a weight loss of 16.89% after 7 days, which then steadily climbed to 38.11% by day 28. However, when vacuum packing was used on the control group, there was a notable decrease in weight loss. Specifically, the weight loss was just 0.39% after 7 days and 3.52% after 28 days. Elevating the melatonin levels to 0.2 mM resulted in further significant decreases in weight loss. After 28 days, the group subjected to non-vacuum packaging suffered a weight loss of 13.35%, while the weight loss was kept to a minimum of 0.54% with vacuum packing. Among all treatments, the 2 mM methyl jasmonate treatment had the most efficacy, resulting in a weight reduction of 5.01% after 7 days, which decreased to 19.96% after 28 days in non-vacuum circumstances. The vacuum packing in this group resulted in a minimal weight reduction of 0.01% after 7 days and just 1.32% after 28 days. The significant decrease in weight of the control fruits may be attributed to their elevated levels of MDA (Okba et al., 2021), which showed serious cell damage caused by lipid peroxidation in cell membranes (Xu et al., 2021). The significant decrease in weight loss % seen in vacuum-packed fruits may be attributed to the wrapping films sticking to the fruit's surface, creating an additional layer that reduces respiration and prevents evapotranspiration losses (Rana et al., 2018). Furthermore, Moradinezhad et al., (2019) found that the application of vacuum significantly decreased weight loss compared to the control samples. They observed that the modified atmosphere surrounding the pomegranate fruit delayed ripening and reduced weight loss, which aligns with the findings of our study. According to (Gao et al., 2016; Chen et al., 2022; and Qian et al., 2024), the rate of weight loss in fruit could be reduced by melatonin treatment, which could help preserve their quality during cold storage. Treatment with MeJA has the potential to mitigate the escalation in weight loss (Wang et al., 2019a).

Respiration Rate (mg CO_2 kg^{-1} h^{-})

Guava is a climacteric fruit that exhibits a significant increase in respiration rate after being stored at ambient temperature (Gill, 2018). Throughout a storage duration of 7, 14, 21, and 28 days, as shown in Fig.2 . The results demonstrate a similar trend across all treatments and storage periods. Upon initial analysis of the respiration rate percentage of guava fruits in non-vacuum packaging, it was observed that the control group exhibited a respiration rate of 55.89 mg CO_2 kg^{-1} h^{-}after 7 days, which gradually increased to 68.70 mg CO_2 kg^{-1} h^{-} by day 28. Conversely, the respiration rate in the vacuum-packed group began at 50.28 mg CO_2 kg^{-1} h^{-} and concluded at 63.67 mg CO_2 kg^{-1} h^{-} throughout the same period. When melatonin was applied at a concentration of 0.1 mM, it caused a reduction in the respiration rate in both groups. However, the vacuum-packed group showed a more pronounced impact. The observed trend persisted when melatonin was administered at 0.2 mM. Similarly, applying methyl jasmonate at concentrations of 1 mM and 2 mM led to a decrease in the respiration rate. The use of vacuum packing demonstrated a more pronounced effect. Due to their direct exposure to the environment, the elevated respiration and evapotranspiration rates seen in control fruits may be attributed to the increased post-harvest weight loss observed in these fruits, as shown in Fig.1. According to a study published by Chen et al., (2022), guavas that were exposed to melatonin during the post-harvest storage period showed a significant reduction in their respiration rate. The study conducted by Liu et al., (2019)"ISSN":"15205118","PMID":"30735384","abstract":"Understanding ripening and senescence processes in postharvest stored fruit is key to the identification and implementation of effective treatment methods. Here, we explored the effects of exogenous applications of melatonin (MT showed that melatonin played significant roles in two processes: it suppressed the expression of ethylene synthetase genes (PcACS and PcACO), thus reducing the rates of respiration and ethylene synthesis in pear fruit.

Furthermore, Gao et al., (2016) discovered that the use of melatonin treatment assisted in maintaining the integrity of the cell membrane. This preservation may contribute to the mechanism that delays the senescence process in fruit. MeJA treatment can reduce the increase in respiratory rate (Shehata et al., 2020). Furthermore, Aslantürk et al., (2022) have also stated that MAP and MeJA treatments will lead to lower consumption of oxygen and the production of carbon dioxide.

Fruit firmness (N/cm^2)

Fruit firmness is a crucial measure of fruit ripeness, and it steadily diminishes as fruit is stored under certain circumstances (Chen et al., 2022). As anticipated, the decline in fruit firmness during storage occurred, as shown in Fig.3. After 7 days, the guava fruits in the control group exhibited a firmness of 545.16 N/cm^2 when stored using non-vacuum packaging. During storage days, the firmness gradually decreased to 218.16 N/cm^2 by day 28. Conversely, the level of firmness in the group that experienced vacuum packaging was measured at 821.66 N/cm^2 and decreased to 369.83 N/cm^2 during the same duration. Significantly, the use of methyl jasmonate at 1 and 2 mM led to a significant rise in firmness when compared to the other treatments. This effect was especially noticeable in the vacuum-packed fruits as opposed to the non-vacuum-packed fruits. The research found that treating MeJA may have a limited effect on preserving guava firmness by minimizing water loss and inhibiting microbial development, as shown in Fig.1 and Table 1. Fruits often experience weight loss and degradation as typical physiological problems throughout the process of post-harvest handling and storage (Lufu et al., 2021)non-perforated 'Decco', non-perforated 'Zoe', micro-perforated Xtend®, 2 mm macro-perforated high density polyethylene (HDPE. Consistent with Fan et al., (2022a); Cai et al., (2024a) findings, melatonin treatments postponed the reduction in fruit firmness and maintained it elevated. (Li et al., 2024)β-glucanase (associated with hydrolysis of cell wall components discovered that melatonin retards the process of postharvest fruit softening by controlling the degradation of cell walls, maintaining membrane integrity, and enhancing antioxidant systems. Similarly, Chen et al., (2022) found that treating post-harvest guava fruit with melatonin helps it maintain an increased level of firmness. As a result, guava fruit treated with exogenous melatonin has a decreased respiration rate (Fig.2) and maintains its firmness during cold storage (Fig.3). LI et al., (2021); Cai et al., (2024b) found that MeJA maintained the firmness of pear and loquat fruits. Furthermore, Ziosi et al., (2008) found that treating with MeJA suppressed the production of ethylene, which in turn controlled the functions of enzymes involved in cell wall metabolism and reduced the rate of fruit softening.

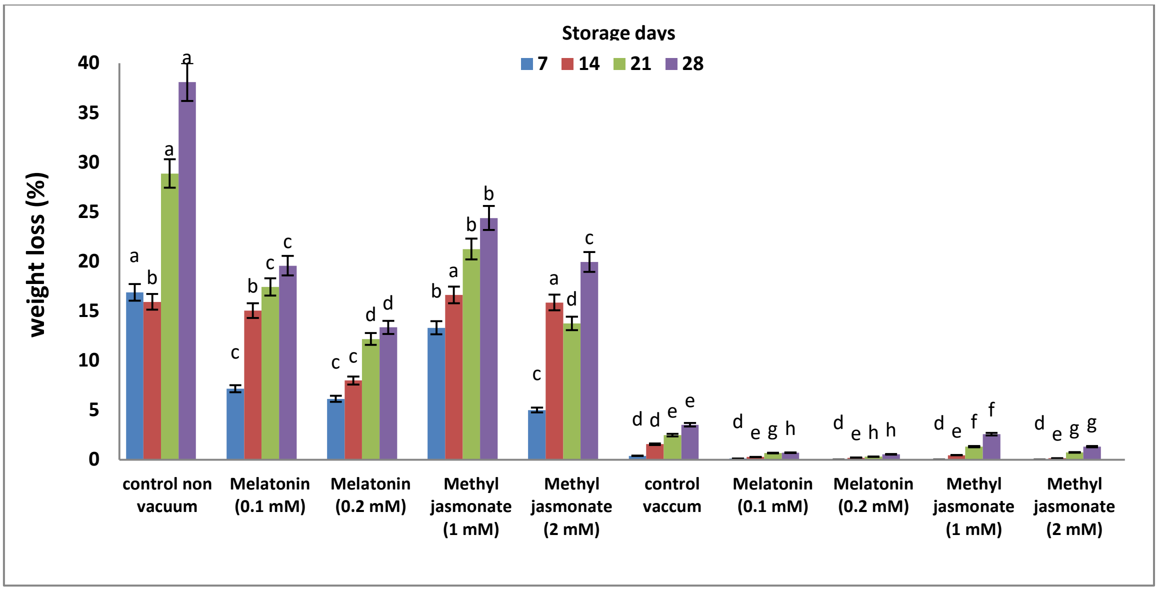

Fig. 1. Impact of melatonin and methyl jasmonate treatments on winter guava fruit under non-vacuum packaging and vacuum packaging conditions on weight loss % during storage.

The different letters denote significant differences according to Duncan's test at p<0.05.

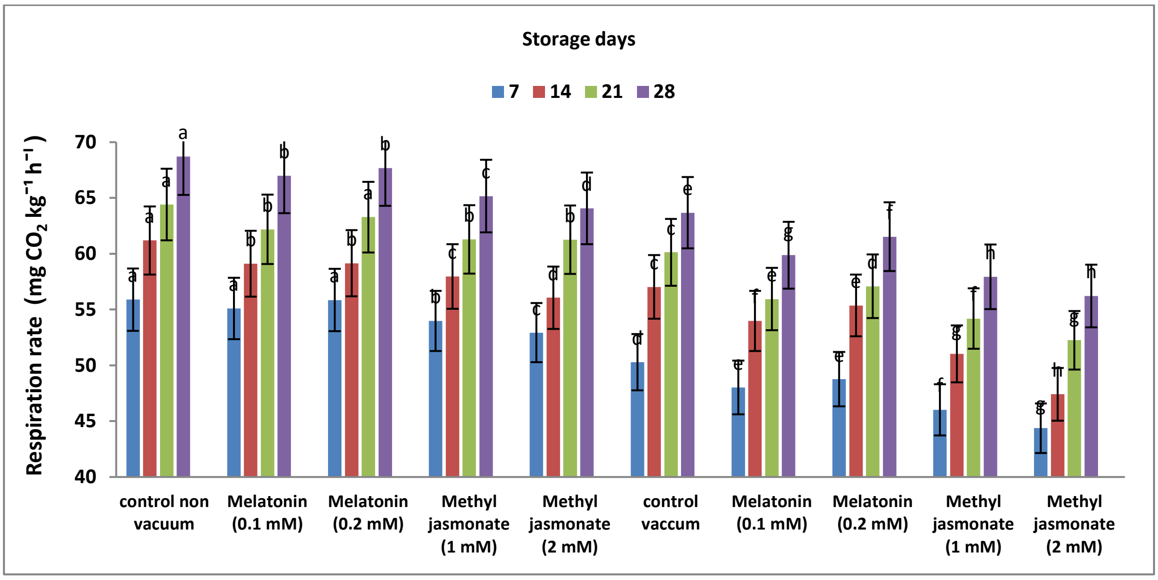

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Fig. 2. Impact of melatonin and methyl jasmonate treatments on winter guava fruit under non-vacuum packaging and vacuum packaging conditions on respiration rate (mg CO2 kg⁻¹ h⁻) during storage

The different letters denote significant differences according to Duncan's test at p<0.05.

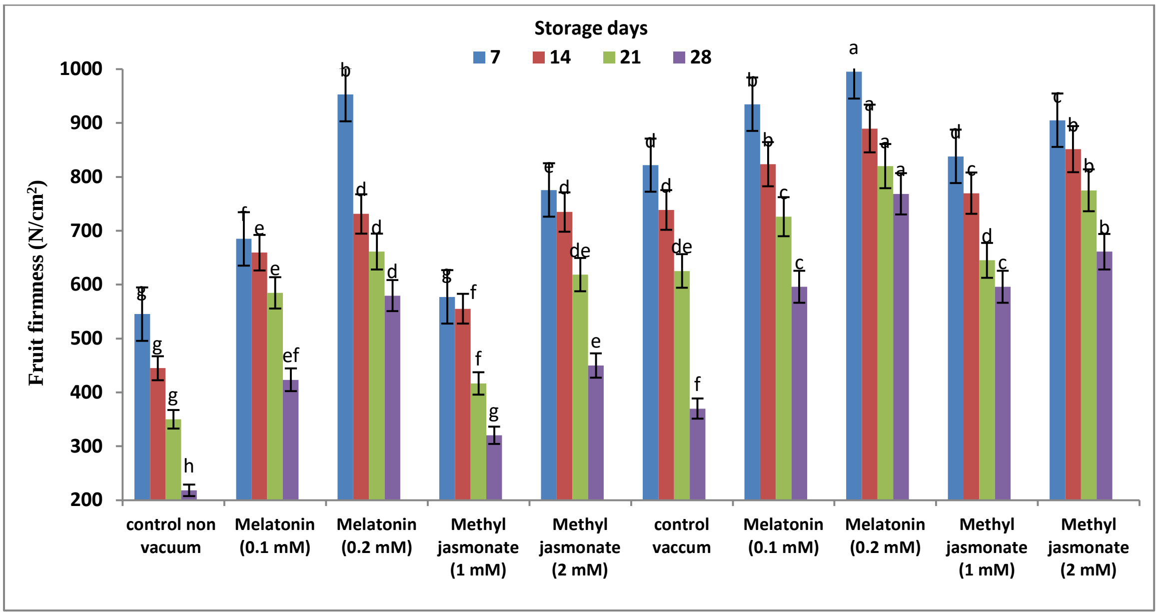

Fig. 3. Impact of melatonin and methyl jasmonate treatments on winter guava fruit under non-vacuum packaging and vacuum packaging conditions on fruit firmness during storage.

The different letters denote significant differences according to Duncan's test at p<0.05.

Total chlorophyll content

The data analysis indicates that vacuum packaging greatly improves the preservation of chlorophyll in guava fruits, as opposed to non-vacuum packaging as shown in Table 3. After 14 days of storage, vacuum packaging increased the chlorophyll content by about 24.8% compared to non-vacuum packaging. Additionally, melatonin was present at a concentration of 0.2 mM, there was a 25.3% increase in chlorophyll content with vacuum packaging compared to non-vacuum packaging. When treated with Methyl jasmonate at a concentration of 2 mM, the increase was 20.3% when using vacuum packing as opposed to non-vacuum packaging. Vacuum packing increased the chlorophyll content by about 38.0% compared to non-vacuum packaging after 28 days of storage. When melatonin was present at a concentration of 0.2 mM and vacuum packing was used, there was a notable and statistically significant increase of 67.6% in the chlorophyll content. When using vacuum packaging, the application of 2 mM of methyl jasmonate resulted in a 30.7% increase compared to non-vacuum packaging. Our analysis found that the chlorophyll content in treated samples was consistently higher than in control fruits at all measured time points Table 3. The levels of oxygen or carbon dioxide may influence the rate at which chlorophyll is produced or broken down and thereby may inhibit the function of carotenoid production enzymes by reducing oxygen absorption (Torales et al., 2020; Krupa and Tomala, 2021)the effect of the concentration of both gases in the cold room on the physico-chemical indices of fruit quality, i.e., mass loss, firmness, soluble solids and monosaccharides content, titratable acidity and acid content, and color of the peel was evaluated. Studies have shown that high CO2 concentrations inhibit ripening processes more effectively than low O2 concentrations. Softening of berries as well as an increase in soluble solid contents was recorded during the first 4 weeks of storage in the fruit. However, the increase in monosaccharides was fairly stable throughout the study period. The increase in soluble solids content as well as the loss of acidity were more strongly determined by CO2 than O2, although the acid content in a 10% CO2 atmosphere did not change. Additionally, the fruits were greener after storage in 10% CO2, but the weakness was skin dulling and darkening. The results indicate that the use of high CO2 concentrations (5–10%. During the storage period, guava fruits receive a color transformation from green to yellow in the fruit peel (Rehman et al., 2020). This change is caused by the degradation of chlorophyll or modifications in the quality and quantity of the green pigment, which occurs due to the activity of enzymes such as chlorophyll oxidase and peroxidase (Valiathan and Athmaselvi, 2018). Vacuum packing creates a modified environment surrounding the fruit, resulting in a high concentration of CO_2. This interferes with the ripening process caused by ethylene and delays the degradation of chlorophyll, thus slowing down the ripening of fruits during storage (Rana et al., 2018). It was also reported that plants treated with melatonin suppressed chlorophyll reduction and retarded color development during storage (Qian et al., 2024). A separate investigation conducted by Chen et al., (2022) revealed that melatonin inhibits the breakdown of chlorophyll in guava peels when they are stored in cold conditions.

Table 3. Impact of melatonin and methyl jasmonate treatments on winter guava fruit under non-vacuum packaging and vacuum packaging conditions on total chlorophyll (µg/ml)during storage

Treatments	14 days		28 days	
	Non-vacuum	**Vacuum**	**Non-vacuum**	**Vacuum**
Control	6.17cd	7.79bc	2.04e	2.95cd
Melatonin (0.1 mM)	7.56bc	9.47ab	2.74de	3.55b
Melatonin (0.2 mM)	7.81bc	9.78a	2.84cd	4.76a
Methyl jasmonate (1 mM)	6.86cd	8.78b	2.69de	3.14bc
Methyl jasmonate (2mM)	7.63bc	9.18ab	2.85cd	3.72b

Different letters denote significant differences according to Duncan’s test (p<0.05).

Fruit Color

Appearance color plays a crucial role in evaluating the ripeness and quality of fruit during harvest, particularly guava (Kashyap et al., 2023), and (Krupa and Tomala, 2021) revealed that the change in peel color is a result of the deterioration of chlorophyll throughout the ripening of the fruits. Our investigation reveals a consistent correlation between the regulatory effects of vacuum packing, as well as melatonin and methyl jasmonate treatments, on the color characteristics (lightness (L*), red/green (a*), and yellow/blue (b*)) of guava during storage, as shown in Table 4. Vacuum packing regularly improves the lightness (L*) and preserves lower red/green (a*) and yellow/blue (b*) values, indicating that it has a substantial impact on maintaining the fruit's visual appeal. Concentrations of methyl jasmonate at 2 mM and melatonin at 0.2 mM are very successful in preserving the desired color properties, such as increased brightness and a shift towards the green and blue spectrums. For example, the lightness (L*), after 14 days of storage, the control group exhibited an L* value of 60.06 under non-vacuum packaging, which increased to 66.90 under vacuum packaging. Among the treatments, methyl jasmonate at 2 mM led to the highest L* value, with 70.45 under non-vacuum and 72.09 under vacuum conditions. Melatonin at 0.2 mM also enhanced the lightness significantly, with a mean L* value of 69.11. By 28 days, the control group's L* value slightly decreased to 57.90 under non-vacuum conditions but remained relatively high at 64.78 under vacuum packaging, with a mean of 61.34. Methyl jasmonate at 2 mM continued to maintain the highest lightness, with values of 68.44 under non-vacuum and 69.87 under vacuum conditions, yielding a mean of 69.15, indicating that this treatment effectively preserved the lightness of the guava fruit over time. The best result was recorded for vacuum packing, together with the application of melatonin and methyl jasmonate, successfully delayed the development of fruit color (measured by L* for lightness, a* for red/green, and b* for yellow/blue) during storage in comparison to the control fruit in combined seasons (as shown in Table 2). These findings align with the outcomes of a prior investigation conducted by Min et al.,(2019), that using vacuum packing demonstrated the ability to successfully retard the enzymatic browning of freshly-cut lotus roots. According to a subsequent investigation by (Cai et al., 2024a; Qian et al., 2024), melatonin treatment comparatively suppressed fruit color development in stored fruit when compared to the control fruit. In this concept Chen et al.,(2022) found that melatonin treatment could delay the increase in skin browning, which skin browning occurs as a result of phenolic oxidation, which leads to the formation of o-quinones. These o-quinones then undergo polymerisation, resulting in the formation of brown pigments. This colour change is undesired and has a detrimental impact on the visual quality of fruits (Geng et al., 2023).

Soluble solids content (SSC%)

As seen in Fig. 4. Throughout the storage period, all treatments exhibited a steady rise in SSC%. Notably, non-vacuum packing consistently resulted in somewhat higher SSC % values compared to vacuum packaging. The application of melatonin and methyl jasmonate had different effects on SSC%. Methyl jasmonate at a concentration of 1 mM closely resembled the control in maintaining the SSC%, while melatonin at a concentration of 0.2 mM, when combined with vacuum packaging, consistently led to lower SSC% values. This suggests that melatonin may have an inhibitory effect on the accumulation of SSC% during storage. The findings of our study align with those of Cai et al., (2024a), who observed that melatonin effectively postponed the decrease in SSC%. In the guava fruit during storage, the SSC% increased, similar to several other results (Elmenofy, 2021; Malik et al., 2021) the gradual rise in free sugars of fruit during storage and the oxidation of organic acids by the respiration process (Khaliq et al., 2015; Parven et al., 2020).

Titratable acidity

The findings indicated a decrease in acidity levels during the storage period as observed in most fruits (Elmenofy, 2021). Organic acids serve as the energy source for fruits throughout the ripening process by enhancing metabolism via the oxidation of acids in the tricarboxylic acid cycle (Batista-Silva et al., 2018). 'Guava' fruit acidity % varied in response to vacuum packaging and dipping treatments during storage periods of 7, 14, 21, and 28 days, revealing noteworthy patterns as shown in Fig. 5. The data demonstrates a continuous pattern in which vacuum packing is more effective in preserving the acidity of guava fruit throughout storage, as compared to non-vacuum packaging. Both the melatonin and methyl jasmonate treatments had a substantial impact on acidity levels. Specifically, the melatonin treatment at a concentration of 0.2 mM consistently demonstrated the strongest retention of acidity during all storage periods. The acidity of the control group consistently dropped with time, but the treatments, especially under vacuum circumstances, effectively alleviated this reduction. The difference between non-vacuum and vacuum packaging grew increasingly evident as the duration of storage increased, emphasizing the significance of packaging techniques in preserving the quality of fruits. The regulatory influence of these treatments indicated that melatonin, particularly at elevated dosages, is more efficacious in maintaining acidity, making it a potentially helpful remedy for prolonging the shelf life of guava. Obtained similar results in passion fruit (Cai et al., 2024a), peach fruit (Gao et al., 2016), and guava fruit (Chen et al., 2022). Due to melatonin and methyl jasmonate, the degradation of organic acids will decrease, resulting maintain in fruit quality(Fan et al., 2022b; Wang et al., 2022).

Table 4. Impact of melatonin and methyl jasmonate treatments on winter guava fruit under non-vacuum packaging and vacuum packaging conditions on fruit colour (L*—lightness, a*—red/green, and b*—yellow/blue) during storage.

L						
Treatments	**14 days**			**28 days**		
	Non-vacuum Vacuum		**Non-vacuum**	**Vacuum**		
Control	60.06e	66.90de		57.90e	64.78c	
Melatonin (0.1 mM)	67.88cd	68.59bc		64.01c	66.63bc	
Melatonin (0.2 mM)	68.99bc	69.24b		67.52bc	68.20ab	
Methyl jasmonate (1 mM)	66.11de	67.23cd		63.13d	66.69bc	
Methyl jasmonate (2mM)	70.45b	72.09a		68.44ab	69.87a	
A						
Control	4.25a	-1.75b		7.34a	0.55c	
Melatonin (0.1 mM)	-2.82cd	-2.09c		1.98b	-0.79d	
Melatonin (0.2 mM)	-2.21c	-4.11e		0.32c	-3.43g	
Methyl jasmonate (1 mM)	2.95-cd	-3.55d		1.05-e	-2.09f	
Methyl jasmonate (2mM)	-3.93d	-7.25f		-1.53ef	-5.39h	
B						
Control	42.22a	41.19ab		46.49a	44.40b	
Melatonin (0.1 mM)	38.12b	37.68b		40.90c	39.38cd	
Melatonin (0.2 mM)	35.43c	35.24c		37.56d	36.73de	
Methyl jasmonate (1 mM)	40.85ab	37.22b		43.40b	28.23e	
Methyl jasmonate (2mM)	36.88bc	35.60c		39.27cd	37.58d	

Different letters denote significant differences according to Duncan's test (p<0.05).

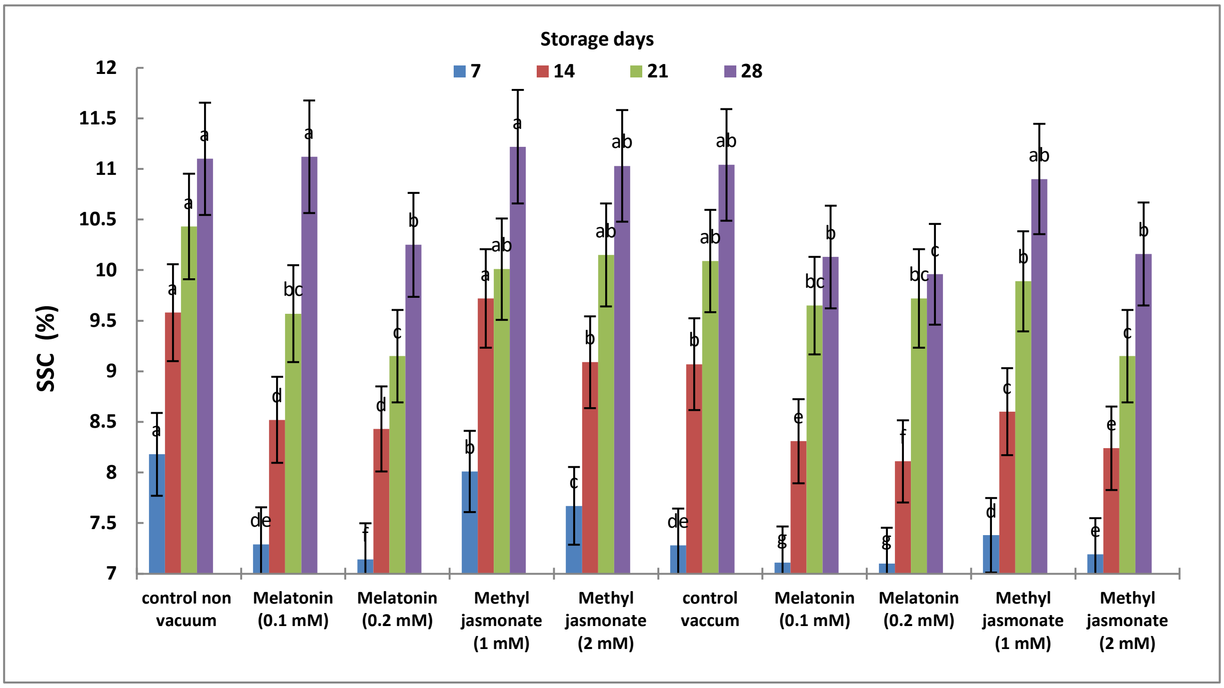

Fig. 4 Impact of melatonin and methyl jasmonate treatments on winter guava fruit under non-vacuum packaging and vacuum packaging conditions on SSC% during storage.
The different letters denote significant differences according to Duncan's test at p<0.05.

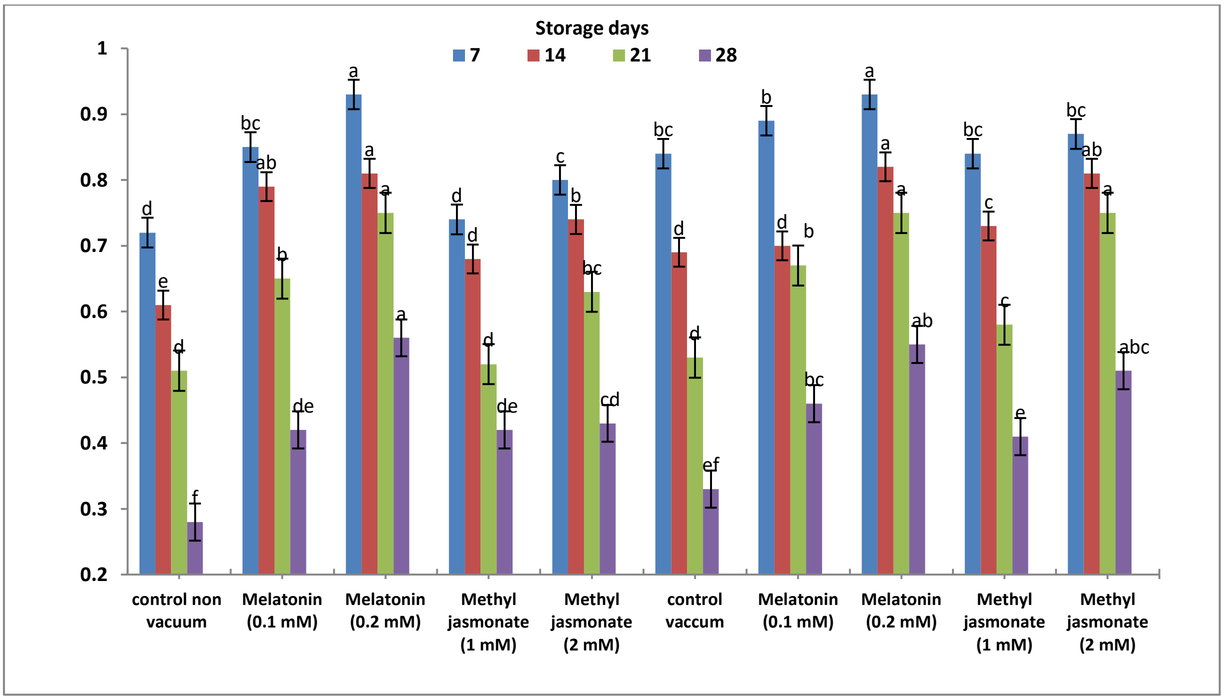

Fig. 5 Impact of melatonin and methyl jasmonate treatments on winter guava fruit under non-vacuum packaging and vacuum packaging conditions on Acidity % during storage
The different letters denote significant differences according to Duncan's test at p<0.05.

Vitamin C content

Vitamin C is a crucial indication of the nutritional worth of fruit, since it functions as a very effective antioxidant (Chen et al., 2022). The concentration of ascorbic acid decreased consistently as the storage time increased, as shown in Table 5. In our findings, vitamin C levels were higher in fruit treated with melatonin and methyl jasmonate alone or in vacuum-packed than in control. The control group exhibited a VC concentration of 98.85 mg 100 g^{-1} after 7 days, which subsequently declined to 87.69 mg 100 g^{-1} by day 28. On the other hand, the group that was vacuum-packed had a vitamin C level of 110.05 mg 100 g^{-1} and 89.57 mg 100 g^{-1}. A concentration of 0.1 mM of melatonin led to a consistent VC content, particularly in the vacuum-packed group, which was further enhanced by a concentration of 0.2 mM of melatonin. Application of methyl jasmonate at concentrations of 1 mM and 2 mM similarly led to the preservation of VC content, with vacuum packing exhibiting a more pronounced effect. Oxidation is a primary catalyst for the reduction of ascorbic acid. Ascorbic acid is often influenced by the presence of oxygen and undergoes oxidation processes (Akram et al., 2017)ascorbic acid (AsA. Melatonin and methyl jasmonate reduce O_2 availability and oxidation, which implies that they prevent vitamin C loss in the altered environment they provide. The research conducted by Cai et al., (2024a), yielded findings, demonstrating that immersing passion fruits in melatonin resulted in a decrease in the loss of ascorbic acid. This was achieved by retaining elevated levels of total phenolic and total flavonoid concentrations. The study conducted by Aslantürk et al., (2022) revealed that the combination of MAP and MeJA resulted in a considerable delay in the loss of ascorbic acid in apricot fruit during storage. Another study by Xie et al., (2024) reported that MeJA maintains the stability of ascorbic acid in kiwifruit. Moreover, the phenolic antioxidants present in essential oils can enhance antioxidant activity, hence leading to higher levels of ascorbic acid in fruits (Bagheri and Esna-Ashari, 2022b)16, and 24 μL L − 1. The effectiveness of methyl jasmonate may be attributed to its ability to reduce the buildup of reactive oxygen species (ROS) in fruits. This decrease in ROS levels helps avoid the loss of vitamin C since the vitamin can scavenge ROS. Additionally, this process enhances the fruit's defence mechanism, as seen by an increase in antioxidant activity (Aslantürk et al., 2022).

Table 5. Impact of melatonin and methyl jasmonate treatments on winter guava fruit under non-vacuum packaging and vacuum packaging conditions on Vitamin C content(mg 100 g−1) during storage.

Vitamin C (mg 100 g^{-1})								
Treatments	**7 days**		**14 days**		**21 days**		**28 days**	
	Non-vacuum	**Vacuum**	**Non-vacuum**	**Vacuum**	**Non-vacuum**	**Vacuum**	**Non-vacuum**	**Vacuum**
Control	98.85e	110.05d	94.59f	98.80e	80.85f	91.45e	77.69e	89.57d
Melatonin(0.1mM)	112.13c	113.16b	106.99ab	107.13a	94.19d	97.16c	91.94cd	92.49c
Melatonin (0.2 mM)	114.82ab	115.83ab	103.86c	106.78ab	98.85b	101.81a	96.89ab	97.13a
Methyl jasmonate (1mM)	112.99c	112.66c	95.13f	101.35d	90.24e	96.25c	78.18de	96.47ab
Methyl jasmonate (2mM)	110.41d	116.94a	105.13b	105.45b	94.43d	99.08b	94.08b	97.14a

Different letters denote significant differences according to Duncan's test (p<0.05).

Conclusions

Egypt's guava export industry is very concerned with guaranteeing the marketability of winter guava fruit and extending its shelf life, while simultaneously limiting any negative effects on fruit quality. The primary limitation of the guava industry is its short post-harvest life, which restricts its ability to be stored for extended periods and marketed to distant locations. Guavas stored at low temperatures experience chilling damage and undergo a decline in fruit quality. In response, our research showed that the application of melatonin and methyl jasmonate treatments on winter guava fruit under non-vacuum packaging and vacuum packaging has a beneficial impact on the quality of fruits. It became obvious that under vacuum packaging. Additionally, the use of melatonin and methyl jasmonate treatments turned out to be a feasible and valuable method for enhancing the quality of winter guava fruit, reducing chilling damage, and preserving fruit quality at a low storage temperature of 4°C, The method may be used in the guava sector to provide extended storage and facilitate transportation to distant markets. Hence, this research recommends the application of A higher melatonin and MeJA concentration to ensure the best quality and storability of winter guava fruit under vacuumed packaging.

Acknowledgements

The authors express their appreciation to the Horticulture Research Institute, Agricultural Engineering Research Institute, and Physiology and Breeding of Horticultural Crops Lab (PBHC), Faculty of Agriculture, Kafrelsheikh University for their assistance to conduct the research study.

Author contributions

H.M.E. N.M.T, and A.M.S. designed the research. H.M.E, N.M.T, and A.M.S. participated in the experiment and data collection. H.M.E. wrote the initial version of the manuscript. H.M.E, N.M.T, and A.M.S. analyzed the data and created the visual work. H.M.E, N.M.T, and A.M.S. did the critical reading and revised the manuscript. All authors read and approved the current version of this manuscript.

Funding

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available on reasonable request.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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الحفاظ على جودة ثمار الجوافة الشتوية (.Psidium guajava L) عن طريق إضافة الميلاتونين وميثيل جاسمونات بعد الحصاد في ظروف التخزين تحت تفريغ وفي درجات حرارة منخفضة

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المستخلص: نظرًا لحساسية ثمار الجوافة الكبيرة لدرجات الحرارة الباردة، وأيضا فإن الجوافة لها قدرة محدودة على التخزين لفترات طويلة. تم إجراء موسمين متميزين حيث تم تخزين ثمار الجوافة الشتوية (*Psidium guajava* L) والمعاملة بالميلاتونين وميثيل جاسمونات (MeJA) تحت تركيزات مختلفة مع التعبئة المفرغة من الهواء عند 4 ± 1 درجة مئوية مع رطوبة نسبية 90 ± 5٪. أظهرت النتائج أن الحمل الميكروبي (CFU / g) انخفض عند معاملة الميلاتونين وميثيل جاسمونات بتركيزات عالية تحت التعبئة المفرغة من الهواء. بالإضافة إلى ذلك، أدت هذه المعاملات إلى انخفاض كبير في نسبة فقدان الوزن. ومع ذلك، لم يتم ملاحظة أي إصابة بالبرودة (CI) في الجوافة عند تخزينها عند 4 درجات مئوية عند معامله الميلاتونين 0.2 mM تحت التعبئة المفرغة من الهواء. في الوقت نفسه، أشارت إلى أن العلاج الأكثر فعالية في تقليل معدل التنفس والحفاظ على حموضة أعلى وحمض الأسكوربيك كان MeJA بتركيز ٢ mM تحت التعبئة المفرغة من الهواء. لذلك، فإن الميلاتونين وميثيل جاسمونات بتركيزات عالية تحت التغليف المفرغ من الهواء يمكن أن يحافظ على تحلل الكلوروفيل بسبب تقليل الليونة ونسبة فقدان الوزن والحمل الميكروبي في ثمار الجوافة الشتوية أثناء فترات التخزين مقارنة بالمعاملات الأخرى والكنترول وبشكل قاطع فإن تطبيق الميلاتونين وميثيل جاسمونات بتركيزات عالية تحت التغليف المفرغ من الهواء أدى إلى تعزيز تحمل التبريد والحفاظ على جودة ثمار الجوافة عند ٤ درجات مئوية لمدة ٢٨ يومًا.

الكلمات المفتاحية: الإصابة بالبرودة؛ فاكهة الجوافة؛ التغليف تحت تفريغ؛ الميلاتونين؛ ميثيل جاسمونات؛ فقدان الوزن.